

Preparations for a storage ring test of a superconductive  
undulator and optimization of the emitted spectra

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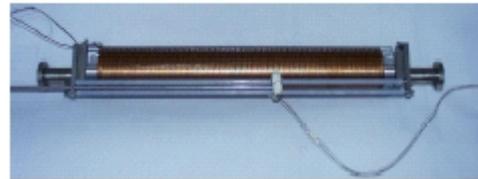
ACCEL Instruments GmbH, Bergisch Gladbach, Germany

## History:

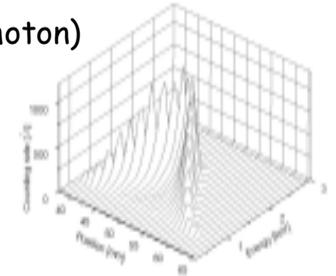
A Karlsruhe-Mainz collaboration tested a sc undulator successfully with beam in Mainz

855 MeV  
100  $\mu$ A cw  
3.8 mm period length  
100 periods  
2 mm gap

One half of the undulator



Measured vertical spectrum  
(single photon)



Can this concept be expanded to a storage ring device:

phase error sufficient?

Current 200 mA?

storage ring vacuum compatible?

insensitive to synchrotron light from nearby bendings?

insensitive to injection?

Search for an industrial partner?

And?

TEST AT ANKA

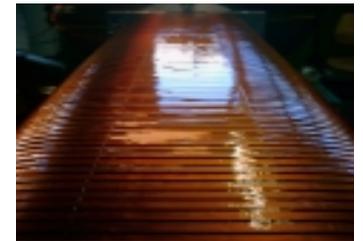
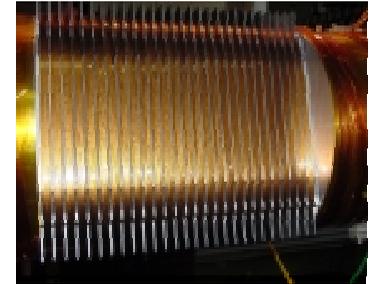
Collaboration with ACCEL Instruments GmbH and National University of Singapore (Prof. Moser)

ANKA: 2.5 GeV  
200 mA  
Injection at 0.5 GeV  
Bunchlength 10-12 mm

Undulator: 14 mm period length  
100 periods  
in steps variable gap:  
open (25 mm)  
5, 8, 12 and 16 mm  
(Cold bore)

Three steps:

- 1.) 10 period, 14 mm period length prototype  
to test phase error and industrial  
production techniques (successfully finished  
Jan.02)
- 2.) Singapore undulator, 50 periods,  
14 mm period length, low beam current,  
Not storage ring compatible (close to finish)
- 3.) ANKA undulator, 100 periods  
(under construction)  
(Talk of Stefan Kubsky this conference)



## Preparations for a European superconductive Undulator

ANKA (Karlsruhe, Germany)

Elettra (Trieste, Italy)

ESRF (Grenoble, France)

Maxlab (Lund, Sweden)



Undulator will be installed at ESRF

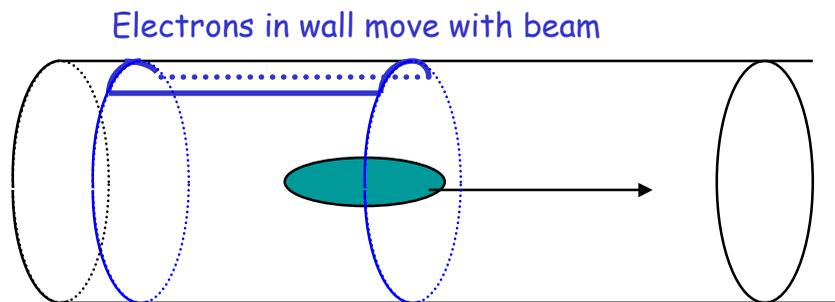
Discussions under way, final decision in autumn

## BEAM TESTS: Topics to be addressed

- A. Heating of the undulator by resistive wall currents
  - B. Storage Ring Vacuum Compatibility
  - C. Heating of the undulator by synchrotron radiation
  - D. Installation at ANKA
  - E. Compensation of unavoidable magnetic field errors
- etc.

## A. Heating of the undulator by resistive wall effect

Assuming Cu foil between  
beam and undulator

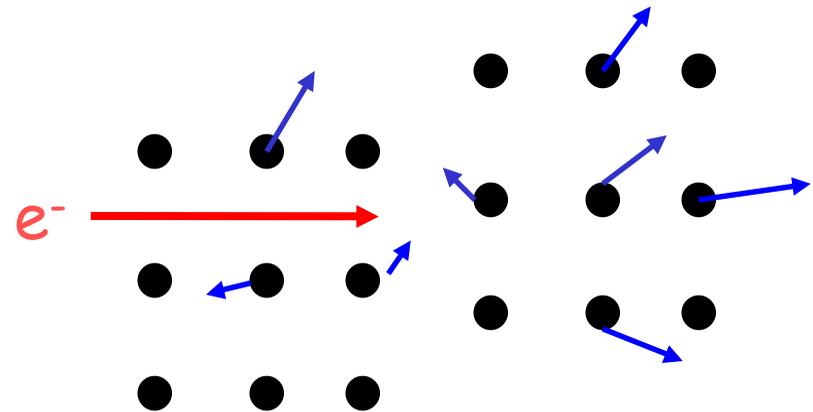


Surface resistance  $R \cong (\rho\omega)^{1/2}$

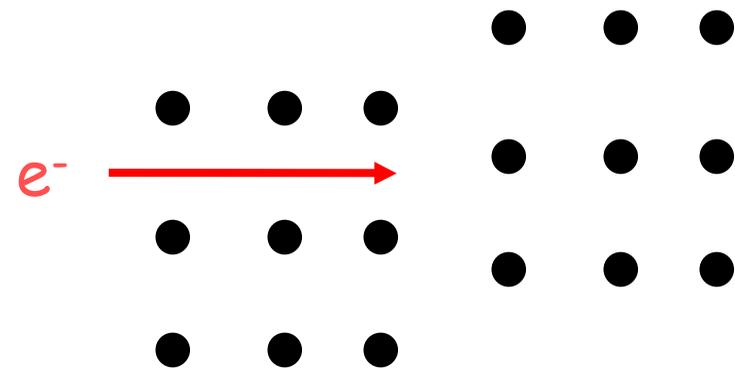
$\rho$  material constant

$\omega$  frequency

High temperature: R defined by  
lattice vibrations and imperfections



Low temperature: R defined by  
imperfections only



Resistivity  $\rho$  [ $\Omega\cdot\text{m}$ ]

Residual resistivity ratio RRR

$$\rho_{\text{room}}/\rho_{4\text{K}} = \text{RRR} > 60 \text{ for Cu}$$

(depends on material quality)

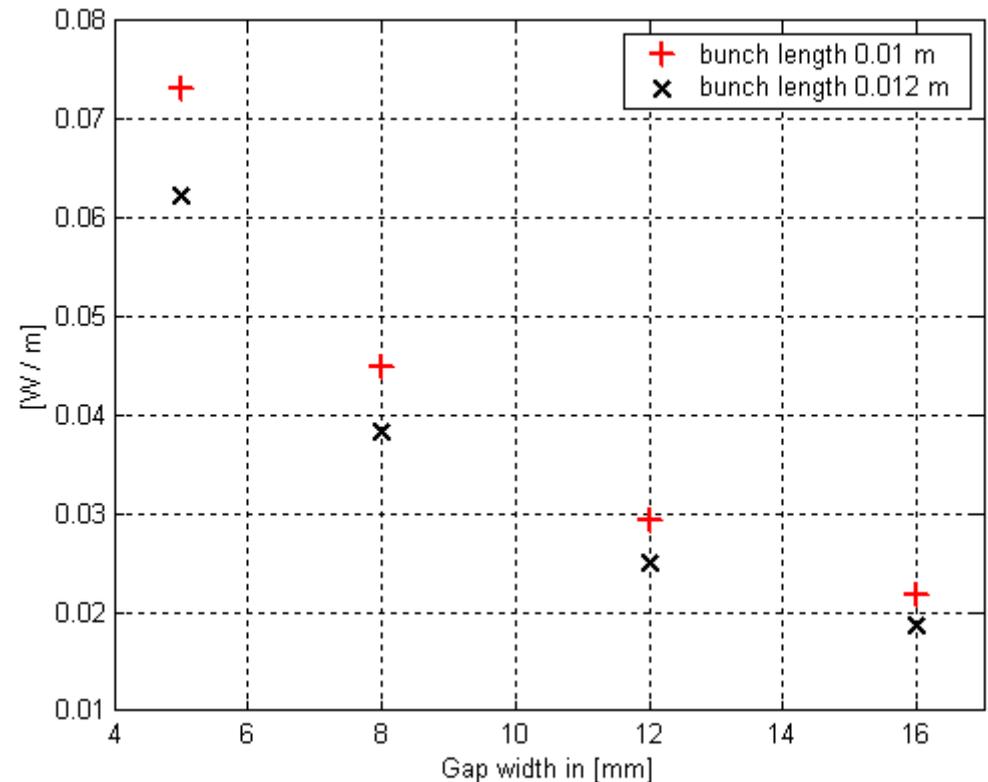
Heating depends on:

current

bunch length

gap width

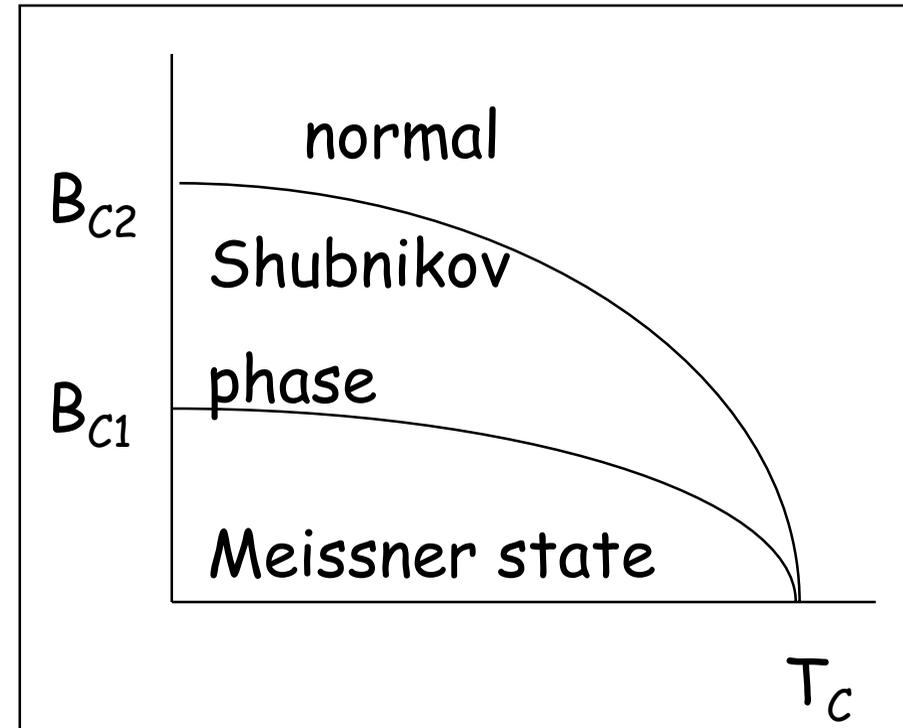
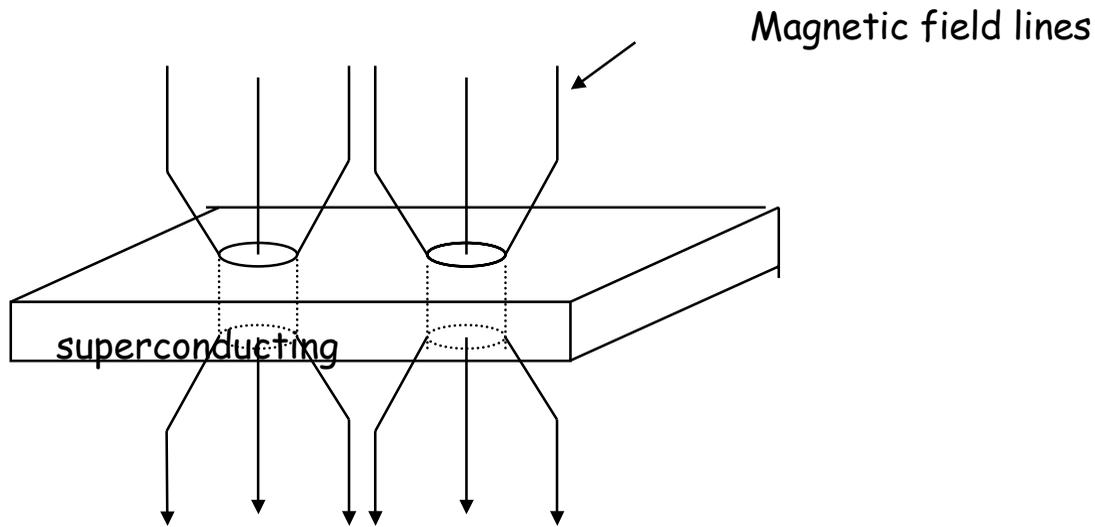
Estimate < 100 - 200 mW/m for ANKA



Not a real problem for ANKA, but for storage rings with short bunch length

Possible way out: sc foil instead of Cu-foil

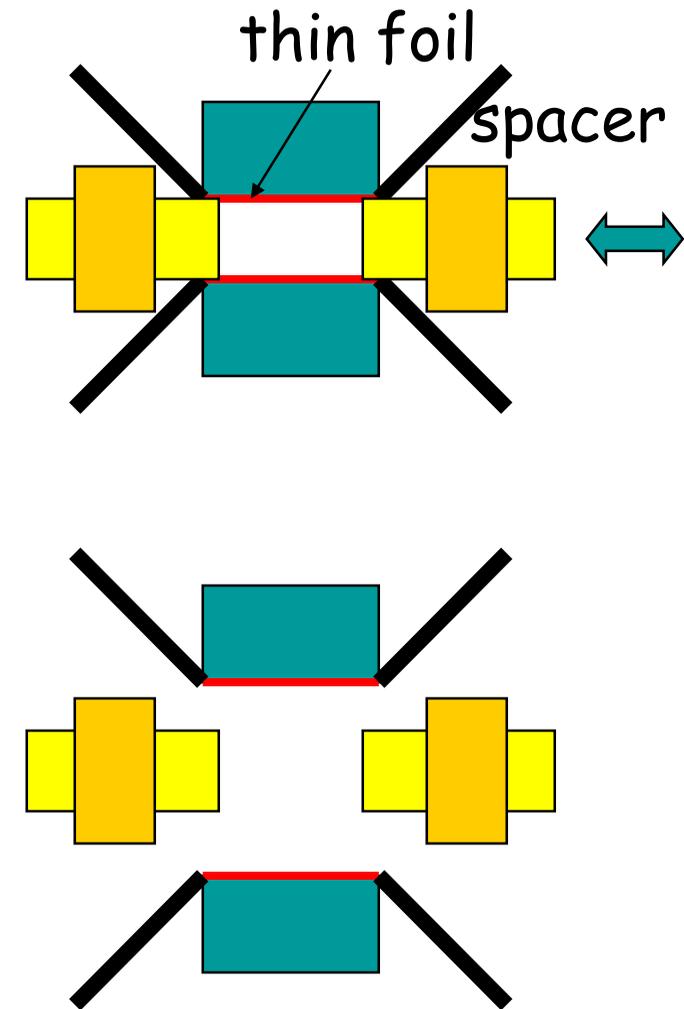
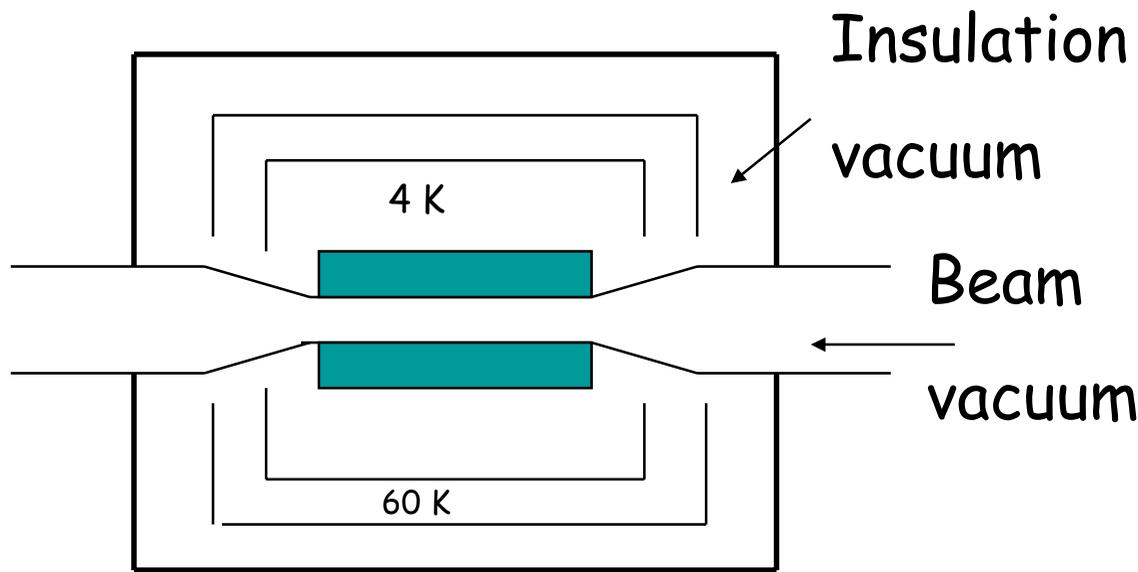
Phase II superconductor



	$T_C$ [K]	$B_{C2}$ [T]
NbTi	10.2	12
Nb <sub>3</sub> Sn	18.3	30
YBa <sub>2</sub> Cu <sub>3</sub> O <sub>6.9</sub>	92	100
Other HTSC	100	1000

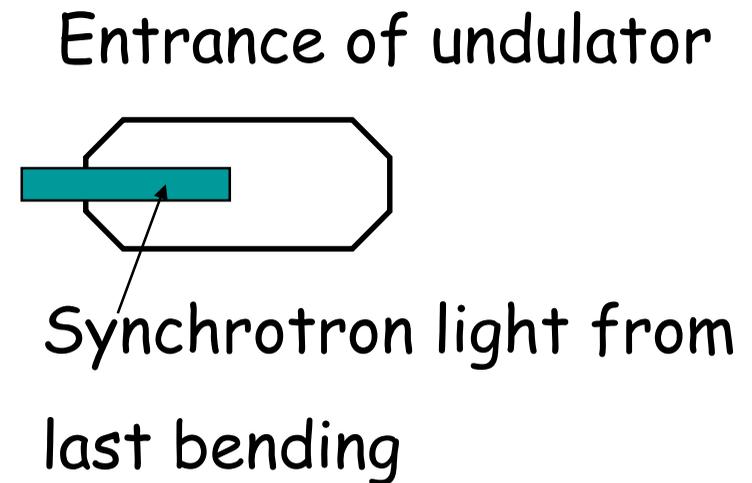
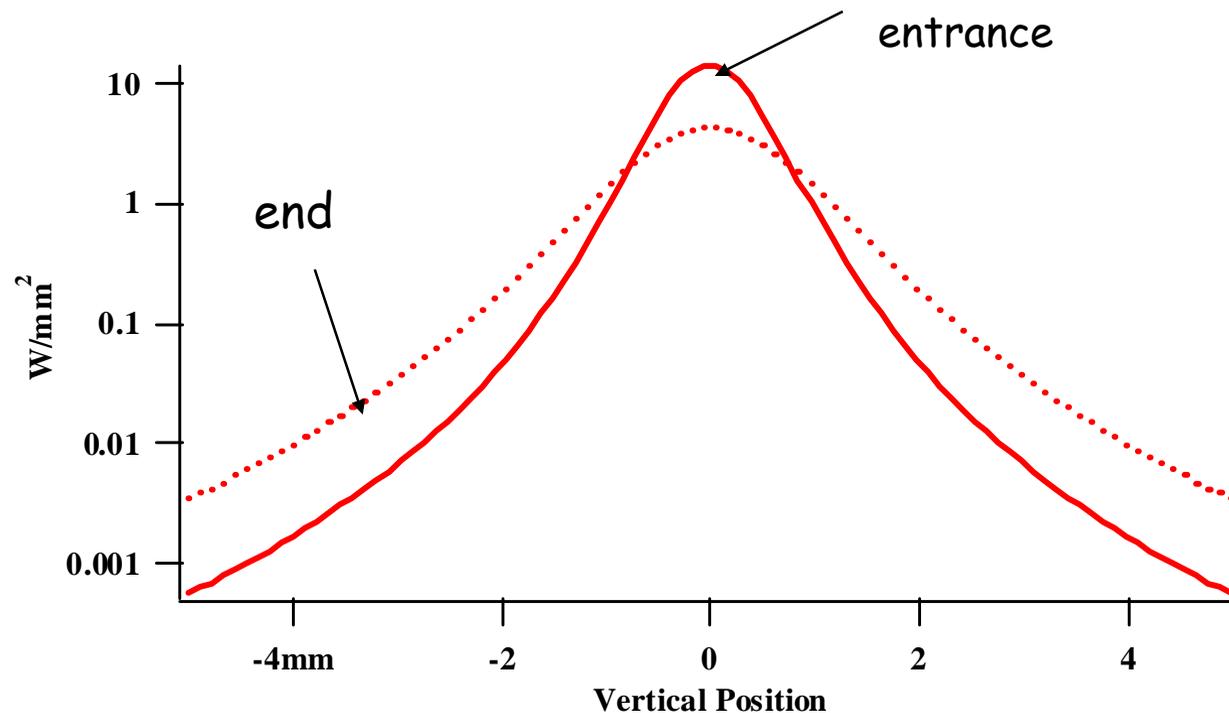
B. Compatibility with storage ring vacuum

Double vacuum system: insulation vacuum  
beam vacuum



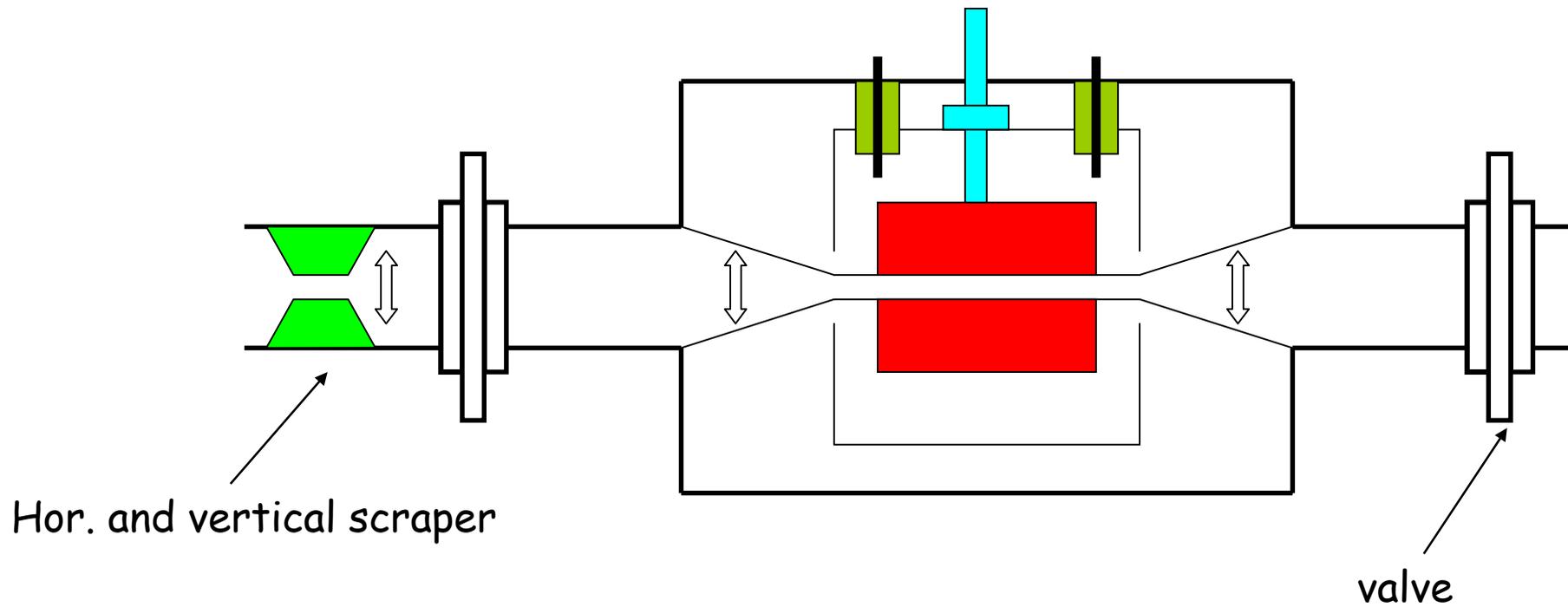
Remains operational, even when one vacuum is broken

## C. Heating of the undulator by synchrotron radiation

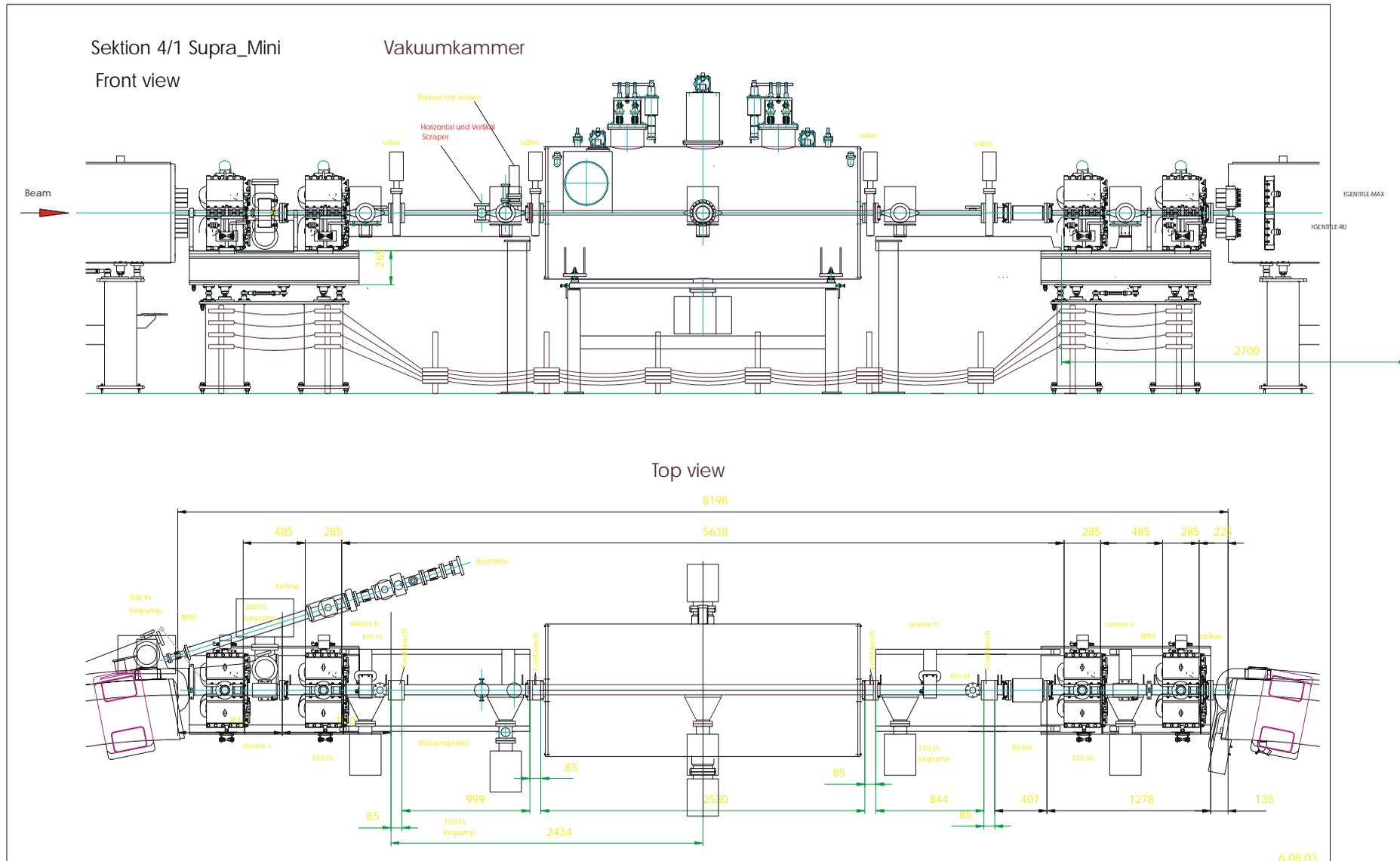


Entrance of the undulator is protected by hor. and vert. Scrapers  
(All calculations: 2.5 GeV, 200 mA,  $\epsilon_z = 0.84$  nm (1% coupling))

D. Installation in ANKA

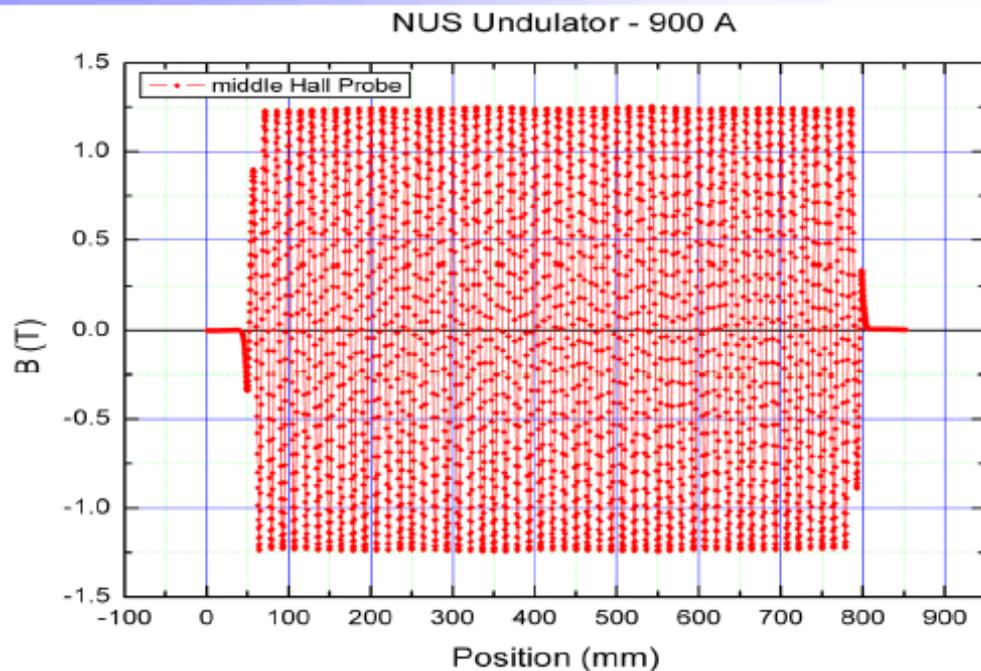


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## E. Compensation of unavoidable field errors

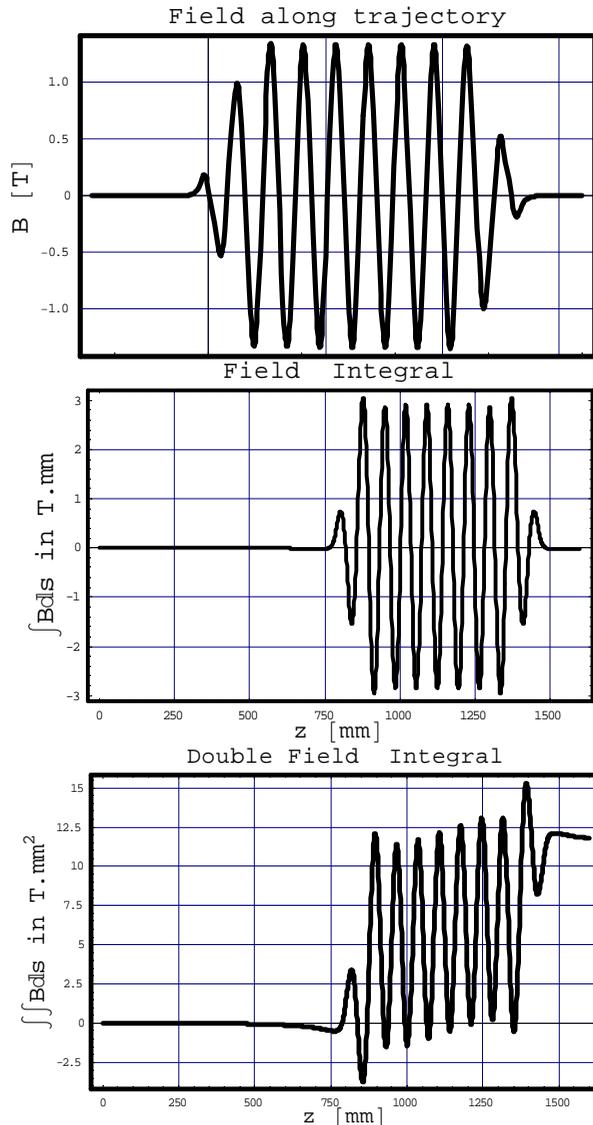
Example NUS- sc-undulator (courtesy National University of Singapore and ACCEL) (Talk by S. Kubsky this conference)



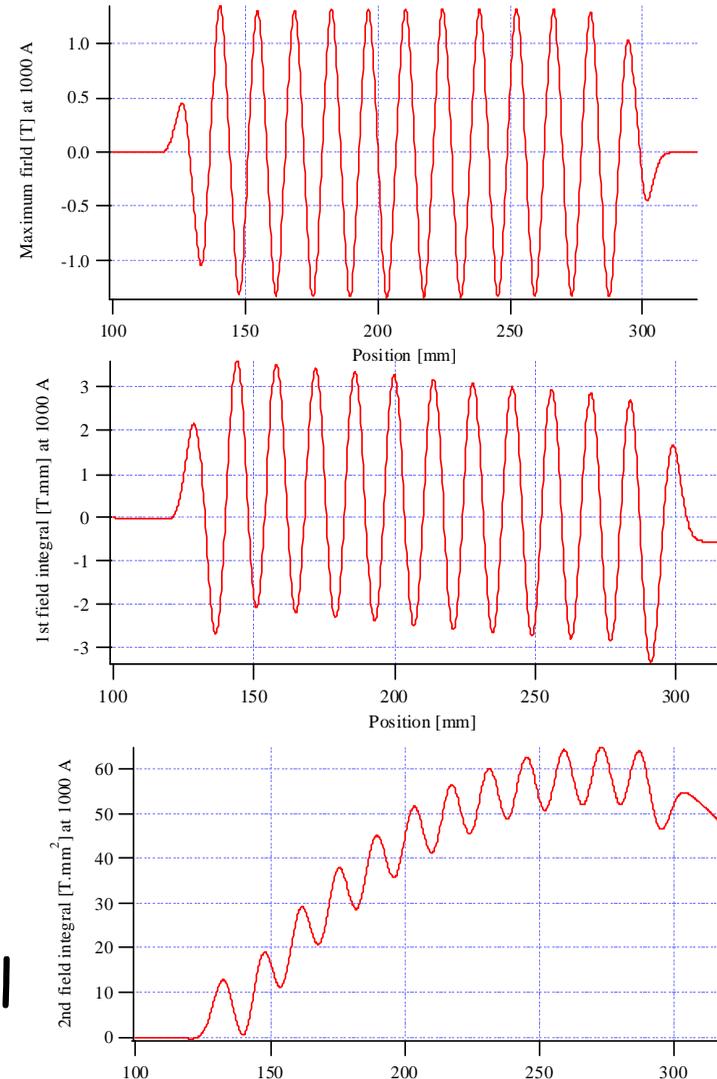
Field error problem is discussed in the following using the 10 period prototype.

Reason: 10 periods are faster to simulate than 50 or 100 periods.

Calculations:  
(3 step matching):



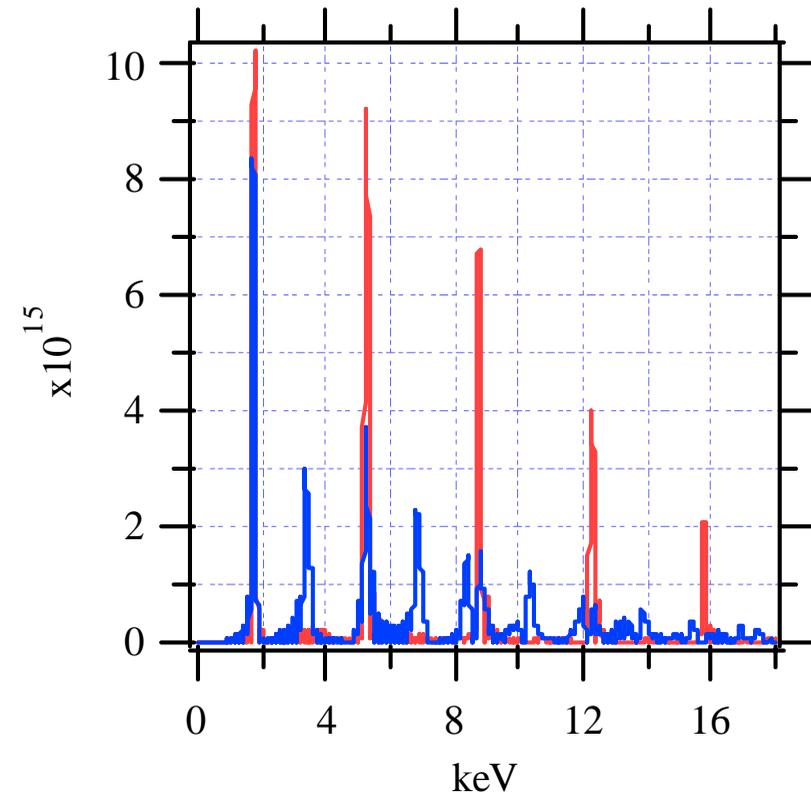
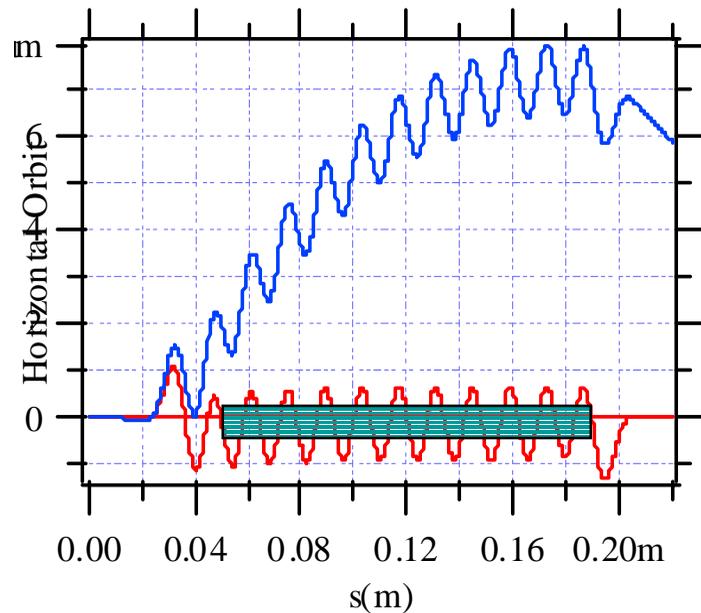
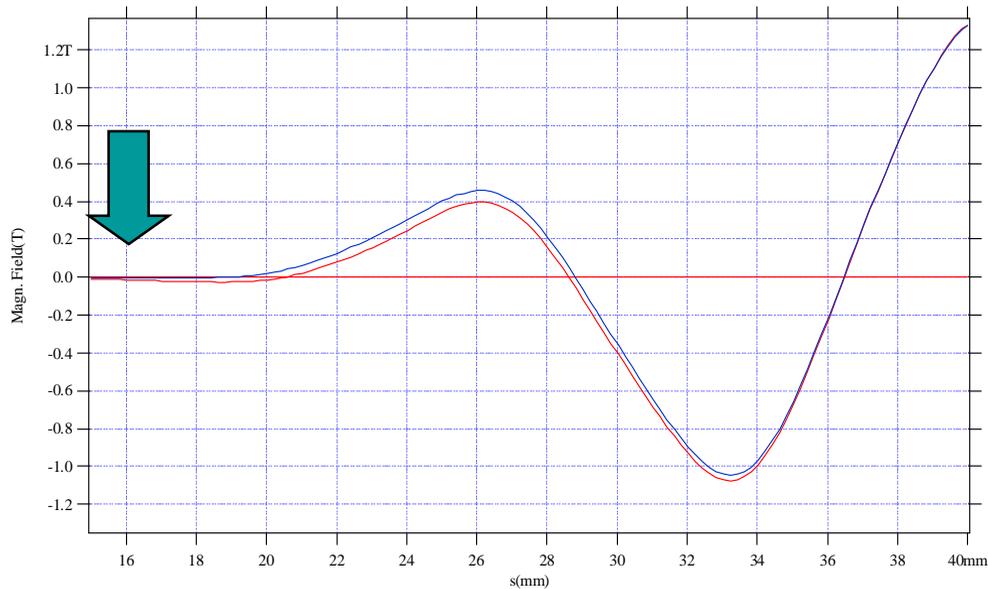
Measurements:  
(2 step matching)



Large  
deviation at  
2 nd integral

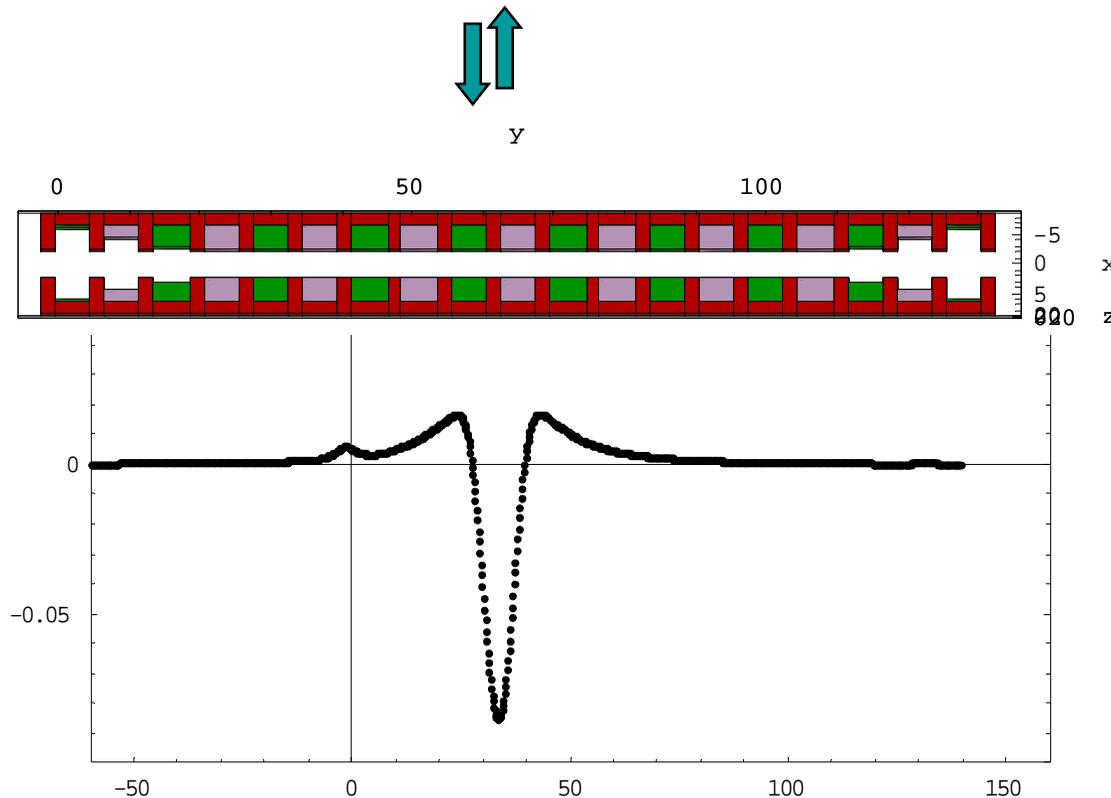
A small field-modification at the entrance (and a weak integral coil) reduces the second integral to zero

On-axis spectrum (ANKA)



In future presumably different technique: electric shimming

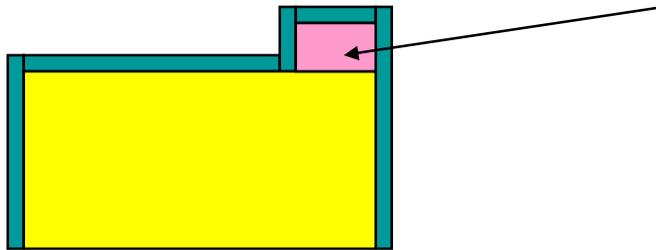
A. Assuming that the kicks are produced by errors in single grooves



Relative  
field change

In this case the basic idea is

1.) Each groove has an additional sc wire (unconnected)



2.) Measurement of field with Hall probes and/or integral

3.) Connecting the identified error sources for the second integral  
to a compensation power supply (and check again)

(Such a system is not implemented in the ANKA undulator)

B. Errors are produced by several grooves: additional coils



Summary:

Experimental test:

- 1.) How does sc undulator behave in real life  
(Synchrotron radiation and wall heating by beam)
- 2.) Optimization of spectrum with 3 correction coils

Next (European?) undulator with electric shimming